

# Weighing the Environment: Ghana's Bui Dam

## Referenced Terms

BPA – Bui Power Authority (Ghana)

EISA – Environmental Impact and Social Assessment (prepared by ERM)

EPA – Environmental Protection Agency (Ghana)

ERM – Environmental Resources Management (British global consultancy)

ESMP – Environmental Social Management Plan (prepared by ERM)

VRA - Volta River Authority (Ghana)

## Introduction

It is 2007 and Ghana is facing a severe energy crisis. For the past year, the country has been experiencing electricity shortages, with frequent and unexpected cuts to power that constrain both daily life and the economy.<sup>i</sup> Electricity prices have increased due to the shortage of supply, and the people of Ghana are frustrated. In attempts to alleviate the nation's power issues, the government of Ghana has drawn up plans to construct a 400 MW hydropower dam at the southern end of Bui National Park, located on the Volta River (Appendix 1). The new Bui Dam is expected to increase the capacity of Ghana's electricity grid by 20 percent and expand the power supply of the Northern and Central regions of Ghana – all welcome additions to the power strapped nation.<sup>ii</sup>

Ebenezer Appah-Sampong, Deputy Director of the Environmental Impact Assessment Department of Ghana's Environmental Protection Agency (EPA), has been tasked with signing the environmental permit that will enable the project to move forward. He is acting on behalf of the EPA's Executive Director, Jonathan Allotey, and while the decision to proceed is collectively made by a cross-sectoral technical review committee, Sampong will ultimately sign for the permit. Only after this permit has been issued may the Bui Power Authority, the body established by the government to manage the hydropower dam project, begin to secure all other permits necessary to begin construction. Concurrently, the Ministry of Finance has been involved in extensive negotiations with China Exim Bank, the primary financier of the dam; all stakeholders will be anxious to begin construction once the agreement is finalized.

Sampong's primary concern is the protection of Bui National Park. At over 1,812 sq. km, it is home to hundreds of species of wildlife, plants and fish. Of those, 19 species, including specific varieties of monkeys, antelopes, and crocodiles, as well as the rare

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*Serena Li conducted interviews and prepared this case under the supervision of Francis Fukuyama of Stanford University. This case was developed solely as a basis for class discussion. It is not intended to serve as a historical record, a source of primary data, or an illustration of effective or ineffective management.*

black hippo, are of significant conservation concern or are protected under Ghana's Wildlife Law (Appendix 2).<sup>iii,iv</sup> A few months ago, Sampong reviewed the Environmental Impact and Social Assessment (EISA), a document that details potential environmental issues arising from construction of the dam and proposed mitigation measures. The EISA was prepared by Eamonn Barrett and his team from the British office of the global environmental consultancy, Environmental Resources Management (ERM).

During preparation of the ESIA, Sampong and his colleagues on the EPA review committee held public hearings on the dam construction. The hearings were attended by representatives from various partner organizations including the Ghana Wildlife Division, the Energy Commission, the University of Ghana, and the Bui Power Authority (BPA), the government body charged with managing the project. The law requires public hearings (similar to the drafting of the ESIA), although such hearings are typically convened after completion of an ESIA. However, keenly aware of the environmental and social challenges created by the last major dam project in Ghana, this time the committee chose to hold the public hearings in parallel with the ESIA process. Sampong, especially, is eager to avoid a repeat of previous headaches.

During the eight public hearings, three main concerns arose: the flooding of the park due to construction of the dam (Appendix 3), the proper management of the park, and the future of communities displaced by the dam. The first two concerns are under the EPA's purview and were important enough that Sampong requested revisions from Barrett's EISA team, seeking additional environmental safeguards for the park.

Now the revisions have come in, along with two new documents that further address the subsequent concerns – an Environment Social Management Plan (ESMP) and a Resettlement Plan Framework. The ESMP is satisfactory to Sampong, and all amendments are in line with Ghana's 1999 Environmental Assessment Regulations (Appendix 4). His counterpart at the BPA is similarly pleased with the adjustments and anxious to have the permit issued.

Sampong's hesitation, however, stems from the stream of unhappy calls and emails he has received from concerned NGOs and civil society groups criticizing the ERM's assessment of issues. Concerns encompass the livelihood of the park's hippos, submergence of 21 percent of the national park area, disregard of downstream communities, and trends in global climate change. According to critics like the Green Earth Organization, International Rivers, and independent research scientists, regardless of any mitigating measures, the dam would be ruinous to the park's existing natural ecosystems and habitats.

Sampong wishes to be a responsible steward of the environment and can empathize with the opposition. He has worked for the EPA for over a decade and wholeheartedly believes in his professional mandate to protect Ghana's natural resources. However, his government colleagues at the various ministries involved are eager for the EPA to issue the environmental permit. Adding to the pressure is the fact that the dam has been over

80 years in the making, and this is the closest the government has come to actually moving forward. What should Sampong do?

## **Overview of Ghana's Electricity Sector**

The electrification of Ghana has progressed steadily since its days as a British colony. From the early 1800s and previous to the country's independence, the region was known as the Gold Coast, and electricity was sparse. Diesel generators operated in isolation by industrial mines and factories provided the initial source of electrical power; these were followed by limited electrical supplies installed in Accra and several other select cities in the 1920s.<sup>v,vi</sup>

In 1957, Ghana achieved independence from Britain, spurring plans for rapid industrialization and driving a need for more extensive power. This demand led to construction of the nation's first hydropower dam in 1962, the powerful Akosombo Dam on the Volta River. With an installed capacity of 1020 MW, the Akosombo Dam was the first project for the Volta River Authority (VRA), a government- mandated agency established in 1961 and charged with development of the Volta River in order to provide electricity in Ghana.<sup>vii</sup> In 1976, the government issued a global tender to build a second dam on the Volta, called the Kpong Hydroelectric Project. Completed in 1982 and also managed by the VRA, Kpong Hydro Plant provided an additional capacity of 160 MW to the country's electricity grid. Together the Akosombo and Kpong Dams provided 1,180 MW of total installed electrical generation capacity – a solid start for a young nation with just over two decades of independence.<sup>viii</sup> This period of dam construction is often seen as Ghana's hydropower years.

As the demand for energy increased, the government looked to diversify its power sources, namely through thermal energy. The VRA oversaw the development of several new thermal power plants, starting with the Takoradi plant in the south, which became operational in 1997. Takoradi II was completed three years later in the same area, bringing the total installed electrical generation capacity of thermal sources to 550 MW.<sup>ix,x</sup> Combined with the hydropower dams, VRA had installed 1,760 MW of generation capacity by 2006 (Appendix 5).

While these new power sources were welcome additions to Ghana's economic development, expansion of the electric grid was not easily achieved. During this time, Ghana experienced two severe power crises, both caused by drought. The first, between 1982 and 1984, saw total inflow to the reservoir of the Volta Basin, source of the Akosombo Dam, drop to below 15 percent of the long-term expected total. Electricity supply tumbled precipitously and was reduced by more than half, forcing the government to ration electricity supply (Appendix 6). A second drought hit the country in 1998, when poor rainfall limited inflows to the Volta Basin. While the decline in supply fell less dramatically than during the drought of the 1980s, the country still experienced frequent power cuts, blackouts, and load shedding (Appendix 7). These two major interruptions reflected the trials of a young nation in its early attempts at development and modernization.

Outside of these periods, however, the hydropower dams generally operated as anticipated, helping Ghana achieve 55 percent electrification by 2005, including about 35 percent of the rural population (Appendix 8).<sup>xi</sup> While electrification was not yet at the level of developed nations, electricity consumption in Ghana had grown 5 percent annually over the previous decade and a half. The rate of electricity consumption was projected to exceed Ghana's overall rate of economic growth (4-5 percent) and population growth (2 percent).<sup>xii, xiii</sup> This healthy demand for power reflected urbanization across the country. It was also bolstered by Ghana's 1989 National Electrification Scheme, a plan to connect all communities of over 500 people to the national grid by 2020. At this point, total domestic and industrial consumption of power in Ghana was projected to reach 11,943 GWh, up about 65 percent from 7,235 GWh in 1997.<sup>xiv, xv</sup> The government also hoped to further engage the private sector in infrastructure development and help to finance and manage large-scale projects. This goal may have set the stage for China Exim Bank and Sinohydro's involvement with the Bui Dam.

## **Bui Dam**

Building the Bui Dam was of interest from the earliest days of Ghana's history. The location was first identified as a promising hydropower site in 1925 by a British-Australian naturalist who visited the Bui Gorge and observed the power of the Volta. Although the colonial administrations of the Gold Coast considered a water development project at the lower reaches of the Volta River,<sup>xvi</sup> construction was not initiated until the 1960s, under Ghana's first president, Dr. Kwame Nkrumah.<sup>xvii</sup>

President Nkrumah hoped the dam would accelerate Ghana's industrialization and modernization, as his country was newly independent of Britain. The dream was short-lived, however, when his government was overthrown in 1966. The project came to a halt. Plans were resurrected shortly over a decade later, with the involvement of Australia and the World Bank. By 1978, the project had reached advanced stages of planning, and all stakeholders were eager to move forward. Unfortunately, political instability once again interrupted plans when the government folded under a succession of military coups.

New efforts to build the dam did not reach fruition again until 2001, under President John Kufuor.<sup>xviii</sup> Anticipation was high. Land had actually been reserved for the very purpose of building a dam. Established in 1971, Bui National Park included more than 1,000 sq. km of land around the Bui Gorge, designated for the future dam.

Given the major costs for the dam, the government again sought external funding. Prospects were dim, however, because dam construction was no longer prevalent in the West. Developed nations were hesitant to provide financing because of growing backlash to the long-term environmental and social impacts of dam construction.<sup>xix</sup> Additionally, the building of the Akosombo and Kpong Dams had been controversial. The Akosombo Dam had displaced over 80,000 local people and was associated with countless other negative environmental impacts such as reduced soil fertility and a rise in fertilizer run-off, which was detrimental to the river waters.<sup>xx</sup> Because of the global disaffection with

dams and the troubled after effects of dam construction in Ghana, it was perhaps unsurprising that when Ghana issued an international call for tenders to build the Bui Dam in 2002, only one bid was received, and ultimately deemed unsatisfactory.

### **Chinese Involvement**

Construction plans were revived a few years later, in 2005, when China Exim Bank (CEB) entered an unsolicited bid to build the dam. A major state-owned bank dedicated to supporting China's foreign trade and investments, China Exim Bank was providing an increasing number of low interest loans to sub-Saharan Africa and was on track to out-lend the World Bank in the region.<sup>xxi</sup> China Exim Bank's interest in the Bui Dam supported China's Going Out Policy, which aimed to promote Chinese foreign direct investment in infrastructure and other projects. Projects like the Bui Dam were favorable to China: among other opportunities, they boosted Chinese exports, provided new business for Chinese contractors, strengthened China's relationship with sub-Saharan Africa, and provided access to valuable natural resources.

Led by Hu Xiaolian, China Exim Bank offered financing in line with China's foreign investment philosophy. No environmental, social, or good governance safeguards were imposed if not demanded by the receiving nation. This approach found favor in many developing countries, particularly those with questionable governance. In Ghana, it enabled the country to overcome financing hurdles in a climate that Western lenders saw as unfavorable to dam construction. After decades of unrealized plans, the actual building of a dam seemed within reach.

China Exim Bank's intended construction partner was Sinohydro Corporation Limited, a Chinese state-owned enterprise with extensive hydropower experience. Sinohydro's participation would be limited to construction only – an arrangement that eliminated responsibility for project details unrelated to the engineering of the dam, such as staffing, budget, and environmental resource management. These administrative elements were to be handled by the BPA. At the time, the BPA was overseen by Fred Oware, a Ghanaian entrepreneur and member of the ruling New Patriotic Party. Oware and his team were to be the mainstay of the project and would manage the entire process, from financing negotiations between China Exim Bank and the Ministry of Finance, to overseeing environmental assessments by ERM, and to hiring local staff to build the dam. They would also supervise dam operations once construction was complete. Through this arrangement, China Exim Bank and Sinohydro effectively limited their involvement to financing and construction.

### **Chinese Loan Terms**

The Chinese loan terms were considered favorable for the Ghanaians. China Exim Bank agreed to take on the majority of financing, providing a \$562 million semi-commercial loan. Of that, \$263.5 million was a concessional loan at a 2 percent interest rate, backed by the Chinese government. This was coupled with a \$298.5 million buyer's credit with a 2 percent interest rate over commercial interest reference rates, backed by China Exim

Bank.<sup>xxii,xxiii</sup> An additional \$60 million was provided by the Ghanaian government via investment, bringing initial total project investment to \$622 million.<sup>xxiv</sup>

While China Exim Bank initially requested a payback period of 17 years, the Ghanaians succeeded in extending the time to 20 years, a favorable arrangement in line with typical payback periods for large dam projects. Hu noted to Oware that she was amenable to providing concessions and making a desirable contract because of the impressive transparency provided by Ghanaian negotiators. She cited her appreciation for the ease of conversation and smooth working relationship, which was unlike her prior experiences with West Africans. Her respect for the Ghanaian negotiators, led by Ghana's Minister of Finance, Kwadwo Bahh Wiredu, helped them achieve an advantageous package. Typically, China Exim Bank offered interest rates of 3.1 percent with a grace period of 4 years, and an amortization of 13 years; the Ghanaians were able to achieve the 2 percent interest rates and 20 year amortization period noted earlier, and a grace period of 5 years.<sup>xxv</sup>

The initial China Exim Bank loans were backed by Ghanaian cocoa; the Chinese government was guaranteed purchase of 30,000 tons of cocoa yearly at world market rates until the dam became operational. Revenue from these sales was held in escrow, as were initial electricity sales. Of this, 85 percent of electricity sales was to be deposited in the escrow account to service the loan, with the remaining 15 percent allocated to cover operational costs of the BPA.<sup>xxvi</sup> This type of arrangement – loans guaranteed through commodities – is called an “Angola model,” patterned after the structure of energy, water and road projects in Angola years earlier.

### **Weighing the Environment**

While Bahh Wiredu and his team at the Ministry of Finance finalize the loan negotiations, Sampong is busy assessing the environmental impact of the dam. Given the history of failed attempts at dam construction, this project is one of the most high-profile that Sampong has undertaken during his 13 years at the EPA. He also faces pressure to rectify the country's power challenges and increase access to electricity.

Sampong is not inherently opposed to building a hydropower facility in the park. Since the national park was cordoned off with the dam in mind, the assumption was that eventually it would be built. To Sampong, the main issue is ensuring that the dam and the park coexist in a positive manner, with minimal impact to the park and its ecosystems. Legally, Sampong must ensure compliance with Ghana's 1999 Environmental Assessment Regulations, which were intended to protect Ghanaian natural resources. The regulations include provisions for the issuance of environmental permits as well as requirements for environmental reports and environmental impact statements.

Although the ERM has assured Ghanaian authorities that any environmental impact will be mitigated, Sampong still has some concerns. Some environmentalists maintain that greater climate macrotrends have been overlooked, specifically the dam's potential contribution to global warming. Critics point out this gap in the environmental

assessment, contending that the ERM underestimated the size of the dam and the significance of its emissions (Appendix 9).

In addition, some NGOs have accused the ERM of myopia, disregarding the effects on upstream and downstream areas. Sampong is unsure of this point, having seen mention of downstream effects in both the environmental assessment (ESIA) and the environment social management plan (ESMP). He has, however, been told that although some of the local people to be resettled rely on fishing for their livelihood, plans to build fish ladders were omitted from the ESIA and subsequent EMSP, since the ERM contends that there are no relevant fish species requiring protection (Appendix 10). This omission is of concern to Sampong.

NGOs like International Rivers have also complained to Sampong that, despite his efforts to conduct public hearings, most of the affected people had no opportunity to voice their concerns. Barrett and his team at ERM, however, maintain that they fully consulted the local communities, with 120 people from different stakeholder groups in attendance (Appendix 11). Sampong is not sure how to weigh these complaints, since his responsibility was limited to managing the process, and he did not personally attend the public hearings.

On the flip side, given the concerns raised at the public hearings, the ERM has been responsive to Sampong's requests for amendments to the environmental assessment (ESIA). The Bui Power Authority (BPA) has also agreed to work with the Ghana Wildlife Division to create an offset - essentially equivalent land set aside to compensate for the 21 percent of the park that will be flooded. The two parties will also find a way to move the hippos further upstream, so that they will not be impacted by the dam.

Additionally, the BPA has agreed to work with the Ghana Wildlife Division to improve park management. Bui National Park has always suffered from illegal poachers, often mining for gold. Such intruders are often foreigners from surrounding countries like Nigeria and Cote d'Ivoire, who illegally enter the forests and may be armed. The Ghana Wildlife Division has struggled to protect the park, and as part of the dam development plans, the BPA has agreed to help strengthen the management of the park with more patrolling and modernization of the infrastructure (Appendix 12).

Finally, although the livelihoods of the resettled communities are technically outside his purview, Sampong is pleased that the BPA has agreed to build a Bui City for the relocation of local people. The planned city will have modern infrastructure, including cement homes with flush toilets, a significant improvement over current earth and mud homes. The BPA has promised to compensate the resettled people fairly and also to link an irrigation scheme for assisting their farming activities. Sampong knows that other terms have been discussed as well, though as an EPA officer, he is not part of those conversations.

## Dilemma

Sampong is at a pivotal point. His government has set a clear priority on proceeding with this dam. The frustrations of Ghanaians over the electricity crisis compound the pressure. Businesses are struggling and some have even shut down because of the unreliable power. Sampong has encountered reports that the mining industry is spending up to \$8.6 million per month on diesel generators to compensate for the power shortfall.<sup>xxvii</sup> The dam will be essential in prevention of similar crises in the future. Additionally, the negotiations with the Chinese have been remarkably smooth and favorable, and the government does not want to lose this valuable financing opportunity.

The Bui Dam has great potential. The additional 400 MW of installed capacity will generate an average of 969 GW annually. The dam is intended to produce power at peak consumption periods and will serve as a source of reactive power for stability across Ghana's electric grid. Furthermore, it will be engineered with the latest technology, which will enhance system voltage regulation, reduce system losses and improve the efficiency of power delivery. It will also enhance the reliability and security of the power supply in Northern and Central Ghana, helping to bridge the gap in development between Ghana's North and South.

Sampong, however, finds it hard to ignore the chorus of complaints from environmentalists and international NGOs. He cares deeply about the environment and the fate of the national park. An environmentalist himself, Sampong empathizes with the concerns of the NGOs and others who have approached him. They have presented valid issues, and he doesn't want this dam to be a repeat of the mess that was Akosombo. What should he do?

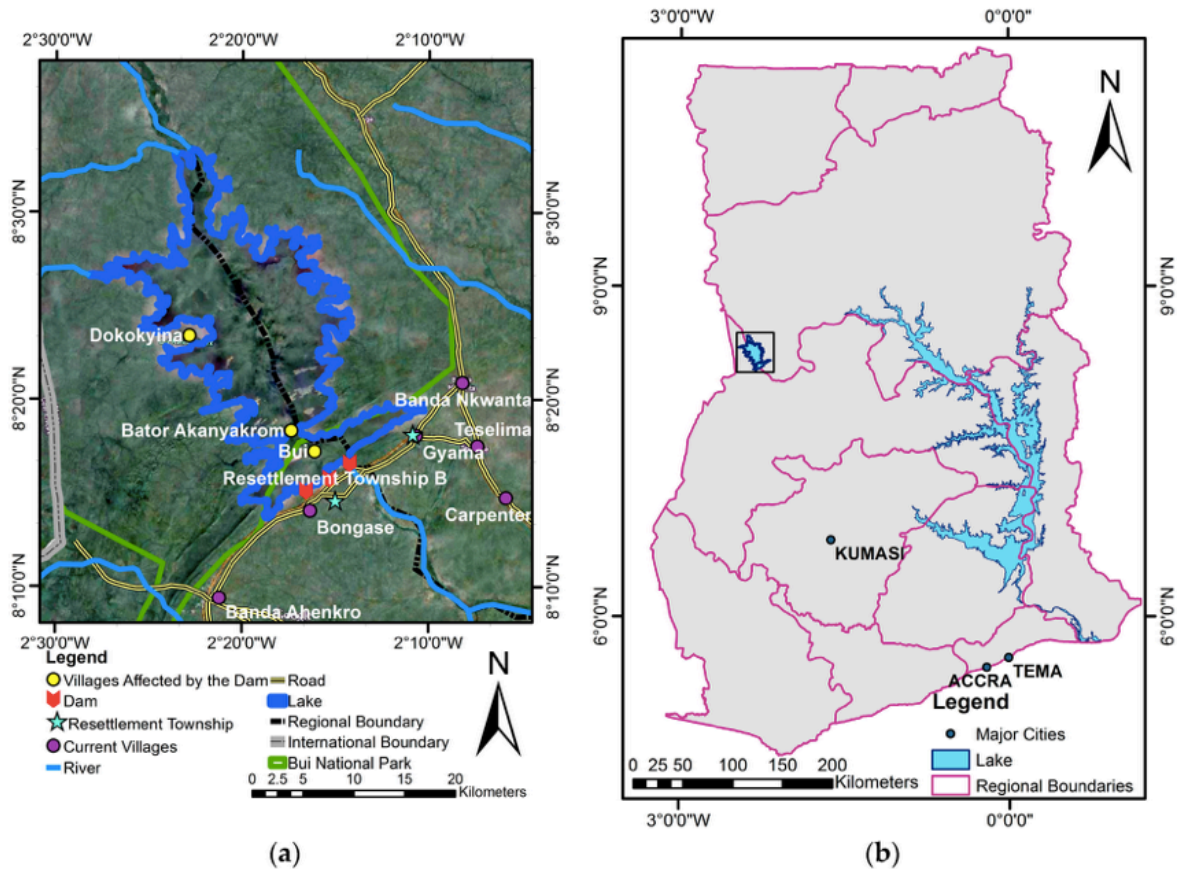


## Appendices

### **Appendix 1: Maps**

Right: Map of Bui Dam, Dam Catchment Area and the Resettled Communities

Left: Map of Ghana, showing the location of the Bui Dam



Source: Asiama, K., Lengoiboni, M., and P. van der Molen. 2017. In the Land of the Dammed: Assessing Governance in Resettlement of Ghana's Bui Dam Project. *Land* 2017, 6(4), 80: doi: 10.339./land6040080 <http://www.mdpi.com/2073-445X/6/4/80>

## Appendix 2: International Union for Conservation of Nature Red List status for the Pygmy Hippo (*choeropsis liberiensis*), the species found in Ghana

### Choeropsis liberiensis



#### Taxonomy [top]

Kingdom	Phylum	Class	Order	Family
Animalia	Chordata	Mammalia	Cetartiodactyla	Hippopotamidae

**Scientific Name:** *Choeropsis liberiensis* (Morton, 1849)

**Common Name(s):**

English – Pygmy Hippopotamus  
 French – Pygmy Hippopotamus, Hippopotamus Pygmy  
 Spanish – Hipopotamo Enano, Hipopotamo pigmeo

Source: IUCN. 2018. The IUCN Red List of Threatened Species. Retrieved from <http://www.iucnredlist.org/details/10032/0>

**Appendix 3: Map of Bui National Park.** Red highlight indicates border of area that will be flooded for the purposes of Bui Dam construction.



Source: Obour, P., Owausu, K., Agyeman, E., Ahenkan, A. & A. Madrid. (2015). The impacts of dams on local livelihoods: a study of the Bui Hydroelectric Project in Ghana, International Journal of Water Resources Development, DOI: 10.1080/07900627.2015.1022892

**Appendix 4: Ghana's 1999 Environmental Impact Assessment Regulations.  
Excerpts from Sections 12 (Draft terms of reference), and 14 (Matters to be  
addressed in environmental statement)**

Draft Terms of Reference

12. The draft terms of reference shall stipulate that the environmental impact statement on the proposed undertaking will deal with matters including the following -

- a. a description of the undertaking;
- b. an analysis of the need for the undertaking;
- c. alternatives to the undertaking including alternative situations where the undertaking is not proceeded with;
- d. matters on site selection including a statement of the reasons for the choice of the proposed site and whether any other alternative site was considered;
- e. an identification of existing environmental conditions including social, economic and other aspects of major environmental concern;
- f. information on potential, positive and negative impacts of the proposed undertaking from the environmental, social, economic and cultural aspect in relation to the different phases of development of the undertaking;
- g. the potential impact on the health of people;
- h. proposals to mitigate any potential negative socio-economic, cultural and public health impacts on the environment;
- i. proposals to be developed to monitor predictable environmental impact and proposed mitigating measures;
- j. contingency plans existing or to be evolved to address any unpredicted negative environmental impact and proposed mitigating measures;
- k. consultation with members of the public likely to be affected by the operations of the undertaking;
- l. maps, plans, tables, graphs, diagrams and other illustrative material that will assist with comprehension of the contents of the environmental impact statement;
- m. a provisional environmental management plan;
- n. proposals for payment of compensation for possible damage to land or property arising from the operation of the undertaking; and
- o. an indication whether any area outside Ghana is likely to be affected by the activities of the undertaking.

Matters to be addressed in environmental statement

14. In submitting an environmental impact statement pursuant to regulation 13(2), the applicant shall indicate in the document a clear assessment of the proposed undertaking on the environment based on the contents of the scoping report.

1. The environmental impact statement shall also address possible direct and indirect impact of the undertaking on the environment at the pre-construction, construction, operation, decommissioning and post-decommissioning phases including

- a. concentrations of pollutants in environmental media including air water and land from mobile or fixed sources;

- b. any direct ecological changes resulting from such pollutant concentrations as they relate to communities, habitats, flora and fauna;
  - c. alteration in ecological processes such as transfer of energy through food chains, decomposition and bio-accumulation which could affect any community, habitat or specie of flora or fauna;
  - d. ecological consequences of direct destruction of existing habitats from activities such as dumping of waste and vegetation clearance and fillings;
  - e. noise and vibration levels;
  - f. odour;
  - g. vehicle traffic generation and potential for increase in road accidents;
  - h. changes in social, cultural and economic patterns relating to
  - i. decline in existing or potential use of valued resources arising from matters referred to in paragraphs (a) to (d) of this sub-regulation.
- i. direct or indirect employment generation;
  - ii. immigration and resultant demographic changes;
  - iii. provision of infrastructure such as roads, schools and health facilities;
  - iv. local economy;
  - v. cultural changes including possible conflict arising from immigration and tourism; and
  - vi. potential land use in the area of the proposed undertaking.

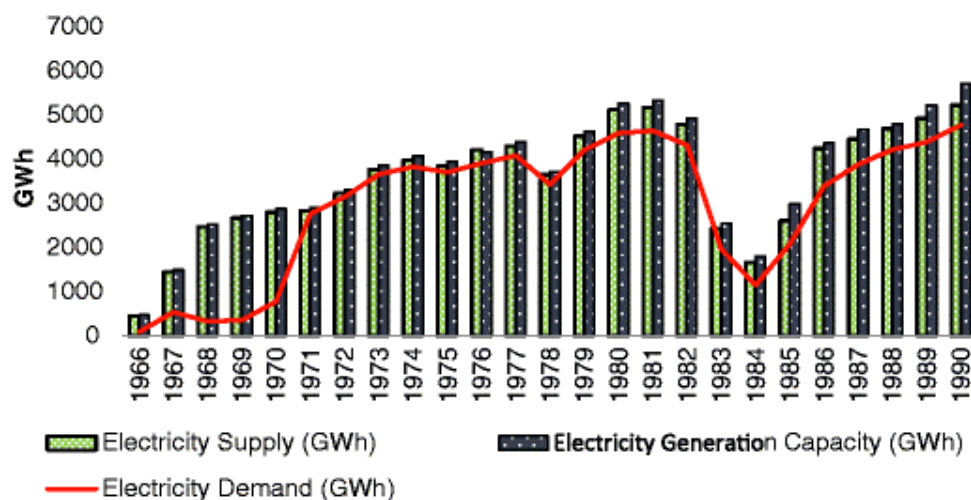
Source: Ghana Environmental Protection Agency. 1999. Environmental Assessment Regulations. Retrieved from <http://extwprlegs1.fao.org/docs/pdf/gha78169.pdf>

## Appendix 5: Installed Sector Electrical Generation Capacity in Ghana, 2006

NAME OF PLANT	INSTALLED CAPACITY (MW)
Akosombo Hydro Plant	1020
Kpong Hydro Plant	160
Total Hydro	1180 (67 % of total)
Aboadze Thermal Plant	550
Tema Diesel Plant	30
Total Thermal/Diesel	580 (33% of total)
<b>TOTAL</b>	<b>1760</b>

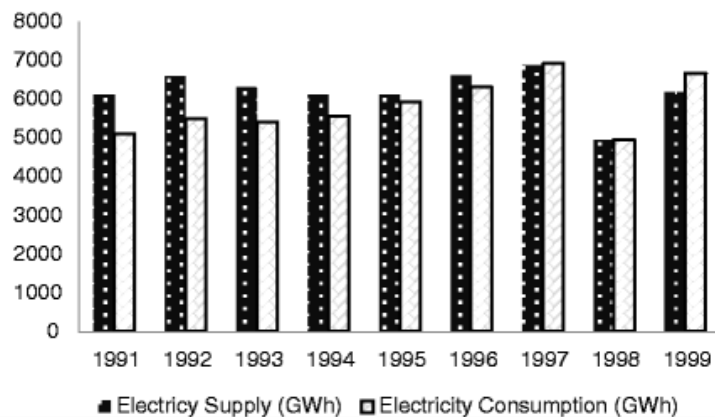
Source: Energy Commission of Ghana. July 2006. Strategic National Energy Plan (2006-2020) – Electricity. Retrieved from [https://new-ndpc-static.s3.amazonaws.com/pubication/Energy+Supply\(Electricity\)\\_Annex+II+to+SNEP.pdf](https://new-ndpc-static.s3.amazonaws.com/pubication/Energy+Supply(Electricity)_Annex+II+to+SNEP.pdf)

## Appendix 6: Trends in Electricity Demand, Supply and Generation Capacity, 1966 – 1990



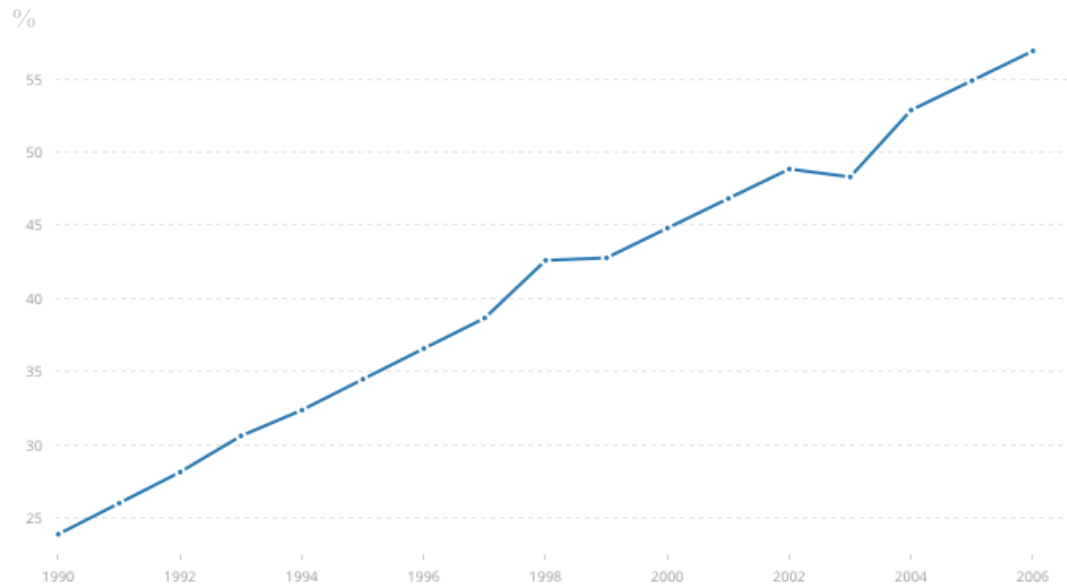
Source: Eshun, M. & J. Amoako-Tuffour. 8 April 2016. A review of trends in Ghana's power sector. *Energy Sustainability and Society*, 6:9. Retrieved from <https://doi.org/10.1186/s13705-016-0075-y>

## Appendix 7: Trends in Electricity Supply and Consumption, 1990 – 1999



Source: Eshun, M. & J. Amoako-Tuffour. 8 April 2016. A review of trends in Ghana's power sector. *Energy Sustainability and Society*, 6:9. Retrieved from <https://doi.org/10.1186/s13705-016-0075-y>

## Appendix 8: Access to Electricity in Ghana by Percentage Population, 1990 – 2006



Source: World Bank. 2018. Access to Electricity - Ghana. Retrieved from <https://data.worldbank.org/indicator/EG.ELC.ACCS.RU.ZS?end=2006&locations=GH&start=1990&view=chart>



## **Appendix 9: Excerpt from Environmental and Social Impact Assessment Regarding Climate Change Trends**

### **10.1 GREENHOUSE GAS EMISSIONS**

Recent studies have suggested that the emission of greenhouse gases (GHG) from reservoirs due to rotting vegetation and carbon inflows from the catchment may be a significant source of global GHG emissions. Greenhouse gases (carbon dioxide and methane) are released into the atmosphere from reservoirs that flood forests and other biomass, either slowly (as flooded organic matter decomposes) or rapidly (if the forest is cut and burned before reservoir filling). Reservoir releases of carbon dioxide and methane are thought to contribute an estimated seven percent of the global warming impact of all human activities.<sup>(2)</sup> The magnitude of the predicted climate change impact at Bui depends on three factors: the amount of biomass that is inundated by the reservoir, the total surface area of the reservoir, and the flux rate. Provided that vegetation is at least partially cleared prior to inundation, greenhouse gas emissions would be relatively low, given that the surface area of the reservoir at FSL (440 km<sup>2</sup>) is not large in comparison to other man-made reservoirs in Africa. The significance of this impact is considered to be minor.

### **10.2 SUSCEPTIBILITY TO CLIMATE CHANGE**

Conversely, a changing climate in turn holds major implications for the safety and performance of dams. Increases in the severity and frequency of droughts would reduce the capacity for hydropower production, and increased floods threaten dam safety, and may increase reservoir sedimentation.

### **10.4 POSSIBLE MITIGATION MEASURES**

Measures to reduce greenhouse gas emissions:

- Consider selected clearance of vegetation prior to inundation.

Source: Environmental Resources Management. June 2006. Environmental and Social Impact Assessment of the Bui Hydropower Project.

## **Appendix 10: Excerpts from Environmental and Social Impact Assessment Regarding Fish Species and Potential Impact**

### **3.5.2 Aquatic Fauna**

#### *Fish*

Surveys in 2001 and 2002 covered four survey locations at the Bui Dam site, the possible reservoir inundation area, and two sites immediately upstream and downstream of these areas, documenting a total of 49 species of fish belonging to 26 genera and 14 families...None of the species encountered during the surveys are of conservation concern: all are known to occur elsewhere in the Black Volta system, including Lake Volta.

#### *Income Dependence*

Many households in the fishing villages supplement their income from fishing with the cultivation of food and cash crops ... It is important to highlight that none of the villages felt that they had access to alternative fishing areas that would bring in the equivalent income, if they were unable fish in their present fishing grounds.

### **7.4.7 Effects on Fish**

#### *Changes in species composition and population density*

A dramatic increase in fish numbers will occur in the first few years following inundation. This will be fuelled by algal growth on the bark of submerged trees (upon which macroinvertebrates feed), providing the foundation for the aquatic food web in the reservoir. Over time, as the reservoir matures, the increase in fish numbers will stabilise and bottomfeeding fish species are likely to diminish in numbers due to sedimentation on the reservoir bottom and subsequent loss of their benthic food supply. The overall impact is therefore judged to be minor.

#### *Effects on migratory fish*

Interruption of the flow regime of the river will have a negative impact on fish species migrating through the downstream sections of the river...Perturbation of the seasonal flow regime will interfere with use of flow and volume cues as migratory triggers, and disturb synergies between these and other environmental cues...Flow perturbations of the magnitude that will be experienced on the Black Volta River as a result of the project are likely to have significant localised effects on the migratory fish community downstream of the dam, but will not affect any rare fish species or cause loss of any species from the system because all species known to occur downstream of Bui are known to occur elsewhere in the watershed. Therefore, the significance of this impact will be moderate.

The dam will block upstream movements of...fish...disrupting spawning activities and ultimately leading to a possible decrease in gene flow and genetic variation between isolated populations in the river. In addition, the blockage and altered downstream flows after completion of the dam could affect the fish communities in Lake Volta. During May and September, certain potadromous fish species...migrate from Lake Volta upstream to spawn in the Black Volta tributaries. If suitable spawning sites for these species do not occur between Lake Volta and the Bui dam site, these species will be lost from this part of the Black Volta system. All of these species are known to occur elsewhere in the Black Volta system, including Lake Volta and none are of conservation concern. As a result the impact is considered to be of minor significance.

Source: Environmental Resources Management. June 2006. Environmental and Social Impact Assessment of the Bui Hydropower Project.

## **Appendix 11: Excerpt from Environmental and Social Management Plan Regarding Stakeholder Groups Consulted**

### *Stakeholders Groups Identified in the Scoping Phase*

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- Villagers in the project area (women, men, chiefs and elders, hunters, fishermen, traders)
  - Newspapers, television and radio
  - Environmental NGOs
  - Social Development NGOs
  - Women's NGOs
  - Government Departments and Agencies (including Wildlife Division, VRA, Energy Commission and others)
  - International donors (DFID, UNDP, EU, World Bank, etc)
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Source: Environmental Resources Management. June 2006. Environmental and Social Management Plan for the Bui Hydropower Project.

## Appendix 12: Excerpt from Environmental and Social Management Plan Regarding Select Recommended Environmental Mitigation Measures

Mitigation Measures	Specific Actions	Responsibility	Timing	Incremental Costs (USD)	Capacity Building and Training Requirements
Issues: Submerged vegetation: will pose a navigation hazard; may deplete reservoir oxygen levels and promote algal and weed growth, and thereby damage fisheries and impair dam operation; may result in hydrogen sulphide production, which may corrode turbines, harm aquatic organisms and produce noxious odours; and will result in the emission of greenhouse gases due to rotting vegetation and carbon inflows from the catchment.					
Selected clearance of vegetation prior to inundation, including removal of tall trees (above 30m; to force tree-dwelling wildlife to migrate from the area prior to flooding), and commercial salvage of trees and forest products.	Design work specification for the clearance of vegetation to be included in contract with Design and Build contractor.	BDS	Prior to tender	-	-
	Complete clearance of vegetation according to this specification, in advance of inundation.	Design and Build Contractor	Year 2 dry season	500 X 20 manmonths labour = 10000, plus 40000 machinery	-
	Monitoring of completion of clearance according to specification, including trigger for halting of inundation if clearance is not satisfactory.	Bui ESMP Team	Prior to closure of diversion outlet in Year 3	Included in core costs (see Chapter 12)	-
Issues: Clearance of vegetation and inundation will result in displacement or drowning of animals. Islands formed in the floodplain during inundation will limit the movement of individual animals.					
Develop and implement a wildlife rescue plan, in coordination with the clearance of vegetation. This should include rescue of rare or distressed animals, strategic fire management, and planting of fodder species (eg <i>Setaria barabata</i> ) favoured by hippopotamus and other species along the littoral zone of the reservoir.	Training of selected Bui National Park officers in Wildlife Rescue	Wildlife Division	Year 1 or Year 2 wet season (ie prior to vegetation clearance)	10,000 X 3 officers = 30,000	Training in wildlife rescue at a national park with regular experience of wildlife rescue.
	Design rescue plan, in coordination with design and build contractors	Wildlife Division and selected National Park officers	Year 1 or Year 2 wet season (ie prior to vegetation clearance)	10,000 fuel and consumables for field visits	
Mitigation Measures	Specific Actions	Responsibility	Timing	Incremental Costs (USD)	Capacity Building and Training Requirements
	Implement plan during vegetation clearance, and during inundation.	National Park management	Year 2 dry season	100,000 to cover equipment	Equipment, including traps, nets, guns, fire control equipment and vehicles.
Begin reservoir inundation after the dry season once hibernating animals have emerged.	Include stipulation in design and build contractors' terms of reference to ensure this.	BDS	Prior to tender	-	

Source: Environmental Resources Management. June 2006. Environmental and Social Management Plan for the Bui Hydropower Project.

## Endnotes

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- <sup>xxiv</sup> The project eventually experienced a funding shortfall, requiring an additional \$168 million in funding which was requested in 2011.

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<sup>xxv</sup> Kirchherr et al, 2016.

<sup>xxvi</sup> Kirchherr et al, 2016.

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